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How to Search the New Annual Index

David M. Liston and **T. Carter Halliday**
Battelle Memorial Institute, Columbus, Ohio

WITH THIS ISSUE, HYDROCARBON PROCESSING AND PETROLEUM REFINER puts before its readers an entirely new annual index covering all articles published during 1963. The new index is what is called an inverted coordinate index and it utilizes the general indexing philosophy and the system of roles of the Engineers Joint Council.[1, 2]

Forming the Search Statement. It is not the proper approach to eliminate terms to make the *initial* question less detailed. An example of the *improper* approach is to change the detailed question, "How should heat exchangers be designed for use in preheating high sulfur gas oils for fluid catalytic cracking units?" to the general question, "How are heat exchangers designed?"

It is also not the proper approach to generalize the terms in the *initial* search question to insure an answer, because by so doing, the capability of the index to screen out broad, general material is not used effectively. Making the question more general by using less specific terms is illustrated by changing the question, "How can the concentration of sulfur as mercaptans in Southern Louisiana Delta Crude Oil be measured by infrared spectroscopy?" to "How can sulfur be determined in crude oil by instruments?"

After the question has been satisfactorily worded both in detail and degree of specificity, the question should be converted to a statement or phrase. For example,

Question: How is polyethylene tubing fabricated?

Statement or phrase: Fabrication of tubing from polyethylene.

A summary of the preliminary steps to be followed in formulating the *initial* search question is

1. Write the question.
2. Use the correct number of terms to make the question adequately detailed.
3. Use the terms that are as specific as the answer desired.
4. Convert the question to a phrase or statement.

Indexing the Inquiry. One way to think of the search statement at this point is to consider it as a brief abstract of each of the articles that the searcher would like to obtain in response to his inquiry.[4] If the search statement (or abstract) matches the abstracts of any articles indexed into the system, then those articles will be retrieved. In order to carry out the actual searching or abstract-matching operation, the *search statement must be converted to term-roles* in the same way the abstracts of the articles were converted to term-roles when the articles were indexed. The matching may then be carried out very simply as described below. See the box entitled "Meaning of Roles" (next page) for a description and examples on the use of roles.

Using the Index. The index to articles published in this issue is an inverted coordinate index, a type of index unfamiliar to many who will be using it. That the index is inverted means that it consists of an alphabetical list-

Short Cut Methods—Editor's Note:

YOU CAN USE the standard system of searching any index when looking for published information in HYDROCARBON PROCESSING AND PETROLEUM REFINER's new type, 1963 index. If you want to find everything we published on heaters in 1963, simply look up the word HEATERS and below it you will find a series of numbers, such as 10-115 (9). The first number "10" refers to the month of publication, the second "115" to the page number. At this point, ignore the "(9)", flip to the first page of the index and under 10-115 read the article title "Rating Fired Heaters."

Coordinate Indexing. Suppose you want to know everything we published in 1963 on HEATER DESIGN. Simply compare the numbers under HEATERS with those under DESIGN and you will automatically retrieve all articles containing information on HEATER DESIGN.

BUT, here's one point we should mention. One of the articles you will get from our index by coordinating HEATERS and DESIGN will be on "Control Valve Selection For Process Use" to be used in heaters. Would you be disappointed if you wanted only articles on heater design and retrieved, in addition, one on the design of control valves *to be used in heaters?*

You might say, "Yes, but everyone knows that you have to go through a lot of unrelated stuff to get the article you need." This is simply not necessary today.

Deep Indexing. We editors think it's time that engineers are not forced to "go through a lot of stuff" to get what they want. We have such a system built right in this year's annual index. If you want to know, "Did you publish any articles in 1963 that give curves or graphs to rate fired heaters and also shows the effect of heat absorption on heater performance?" Our new index can answer that question and provide such an article. It can also answer any other detailed, specific literature search question. This article tells you how to make such a deep retrieval using our 1963 Index.

The Meaning of Roles

ROLES ARE NUMERICAL symbols appended to terms to indicate the context in which a term has been used in the articles indexed, in the indicative abstracts of their contents, and in search statements prepared to retrieve the articles. Since HP/PR editors have used EJC Roles in indexing all the articles published in 1963, the searcher must use the EJC Roles in indexing his inquiry before approaching the index to retrieve article indentifying numbers. The EJC System utilizes eleven roles to represent eleven different contexts in which terms may be used. The roles and their meanings are outlined in Table 1.[1]

The most general or broad type of inquiry (which could serve as a practical search statement) would consist of one term combined with a role, that is, a single term-role. Using examples of this most general type of inquiry for each of the roles, it can be seen how the one-term inquiry converted to a search statement is further converted to a term-role for searching.

Example—Role 8. The inquiry. "In which articles has heat transfer been the primary topic of consideration?"
The search statement. "The primary topic of consideration is heat transfer."
The term-role. HEAT TRANSFER-8.

Example—Role 1. The inquiry. "What information on butane as a raw material is in the collection?"
The search statement. "The primary topic of consideration is some unspecified process with butane as a raw material."
The term-role. BUTANE-1.

Example—Role 2. The inquiry. "Do we have any articles which discuss processes or operations where isopentane is produced?"
The search statement. "The primary topic of consideration is some unspecified operation or process which produces isopentane."
The term-role. ISOPENTANE-2

Example—Role 3. The inquiry. "Which articles discuss methylethyl ketone as an unwanted constituent?"
The search statement. "The primary topic of consideration is some unspecified subject in which methylethyl ketone was unwanted or undesirable."
The term-role. METHYLETHYL KETONE-3

Example—Role 4. The inquiry. "Do we have any articles where pumps have been mentioned for possible application of our products?"
The search statement. "The primary topic of consideration is some unspecified subject concerned with applications in pumps."
The term-role. PUMPS-4.

Example—Role 5. The inquiry. "Which articles mention the use of carbon tetrachloride as a solvent?"
The search statement. "The primary topic of consideration is some unspecified subject wherein carbon tetrachloride was a solvent."
The term-role. CARBON TETRACHLORIDE-5

Example—Role 6. The inquiry. "In which articles is temperature discussed as an independent variable?"
The search statement. "The primary topic of consideration is the effect of temperature on other unspecified properties or characteristics."
The term-role. TEMPERATURE-6

Example—Role 7. The inquiry. "Is there any information on conversion being affected by other operating variables?"
The search statement. "The primary topic of consideration is conversion being affected."
The term-role. CONVERSION (CHEMICAL)-7

EJC Role 9 has three separate meanings as can be seen from Table 1. For this reason it would not be very good practice to use Role 9 in conjunction with single term search strategies. When searching for articles involving any one of the three meanings of Role 9, the results of the search would always include articles involving the other two meanings as well. The proper use of Role 9, which is used in multi-term searches, will be amply demonstrated in the examples of more complex searches.

Example—Role 10. The inquiry. "Do any articles discuss the use to which computers have been put?"
The search statement. "The primary topic of consideration is some unspecified subject in which computers have been used to accomplish something."
The term-role. COMPUTERS-10

Example—Role 0. The inquiry. "Which documents were written involving A.I.Ch.E.?"
The search statement. "The primary topic of consideration is the unspecified subject involving A.I.Ch.E."
The term-role. A.I.Ch.E-0

In most situations the inquires will be more specific than those in the examples above, i.e., inquiries are more likely to require two, three, four term-role combinations, or as many as necessary for the desired level of detail. In the next series of examples, progressively more detailed and more specific inquires are developed. Each example includes the conversion of inquires first into search statements and then into term-roles.

Examples of Searches Requiring Two or More Term-Roles. The inquiry. "In which articles has heat transfer in catalytic cracking been discussed?"

The search statement. "The primary topic of consideration is heat transfer in catalytic cracking."
The term-roles. HEAT TRANSFER-8, CATALYTIC CRACKING-9 (Role 9 is used here in the locative sense)
The inquiry. "Is there any information on the synthesis of benzene from cyclohexane?"
The search statement. "The primary topic of consideration is the synthesis of benzene from cyclohexane."
The term-roles. SYNTHESIS-8, CYCLOHEXANE-1, BENZENE-2.
The inquiry. "Have storage tanks ever been cleaned by sandblasting?"
The search statement. "The subject reported is the cleaning of tanks used for storage by sandblasting."
The term-roles. CLEANING-8, TANKS-9, STORAGE-4, SANDBLASTING-10 (Role 9 is used here to show passive receiver of an action)
The inquiry. "How does the concentration of tetramethyl lead affect the road octane of gasoline?"
The search statement. "The principal subject of discussion is the effect of the concentration of tetramethyl lead on the road octane number of gasolines."
The term-roles. CONCENTRATION-6, TETRAMETHYL LEAD-9, ROAD OCTANE NUMBER-7, GASOLINE-9, (Role 9 is used here in the possessive sense), (Role 6-7 implies EFFECT-8).

TABLE 1—Meanings of Roles in the EJC System

Role 1 Input; raw material; material of construction; reactant; base metal (for alloys); components to be combined; constituents to be combined; ingredients to be combined; material to be shaped; material to be formed; ore to be refined; sub-assemblies to be assembled; energy input (only in an energy conversion); data and types of data (only when inputs to mathematical processings); a material being corroded.

Role 2 Output; product, by-product, co-product; outcome, resultant; intermediate product; alloy produced; resulting material; resulting mixture or formulation; material manufactured; mixture manufactured; device shaped or formed; metal or substance refined; device, equipment, or apparatus made, assembled, built, fabricated, constructed, created; energy output (only in an energy conversion); data and types of data (only as mathematical processing outputs).

Role 3 Undesirable component; waste; scrap; rejects (manufactured devices); contaminant; impurity, pollutant, adulterant or poison in inputs, outputs, environments, and materials passively receiving actions; undesirable material present; unnecessary material present; undesirable product, by-product, co-product.

Role 4 Indicated, possible, intended present or later uses or applications. The use or application to which the term has been, is now, or will later be put. To be used as, in, on, for, or with; for use as, in, on, for, or with; used as in, on, for, or with; for later use as, on, in, with

Role 5 Environment; medium; atmosphere; solvent; carrier (material); support (in a process or operation); vehicle (material); permeating gas; permeating liquid; host; adsorbent; absorbent

Role 6 Cause; independent variable; influencing factor; controlled variable; "X" as a factor affecting or influencing "Y"; the "X" in "Y" is a function of "X"

Role 7 Effect; dependent variable; influenced factor; dependent variable; "Y" as a factor affected or influenced by "X"; the "Y" in "Y is a function of X"

Role 8 The primary topic of consideration is; the principal subject of discussion is; the subject reported is; the major topic under discussion is; there is a description of

Role 9 Materials, substances, mixtures, properties characteristics, conditions, qualities, devices, equipment, apparatus, methods, energy forms, data either when: passively receiving an operation or process with no change in composition, configuration, dimensions, molecular structure, physical state, or physical form, or when: preceeded by the preposition of, in, or on meaning possession or location

Role 10 Devices, equipment, apparatus, operations, processes, methods, procedures, techniques, test methods, analytical methods, process conditions, materials, classes of uses of materials, forms of energy, or inspection methods when used as means to accomplish the primary topic of consideration or other objective

Role 0 Or personal names of authors; corporate authors and sources; institutional authors and sources; names of divisions, departments, plants, and laboratories; types of documents; cities, counties, states, countries; names of bodies of water; dates; adjectives; journals and other publications; all other proper names except trademarks.

ing of all terms which have been used in describing information in the articles. With each term are listed the identifying numbers of the articles which were indexed by that term. That is, a coordinate index means that information is located by coordinating two or more terms. Through these coordinations, the search statement, which describes the information we seek, is recreated from the entries in the index. We select from the index those term records which correspond to the terms in the search statement. The manipulation of these term records to identify pertinent articles is the process of coordination.

Let's demonstrate by performing the coordination of terms for the following inquiry example:

Example.

The inquiry. "Are there any articles which discuss the synthesis of cyclohexane from benzene by means of hydrogenation?"

The search statement. "The primary topic of consideration is the synthesis of cyclohexane from benzene by hydrogenation."

The term-roles. SYNTHESIS-8, BENZENE-1, CYCLOHEXANE-2, HYDROGENATION-10.

Figure 1 which shows four examples of term records similar to those in the real index will be used for demonstration. The searcher locates the two terms SYNTHESIS and CYCLOHEXANE in the index (Figure 1).

Next he compares the numbers of the articles listed under each term. In Figure 1 the searcher will notice that each article number listed under a term consists of four parts:

1. The number preceding the hyphen is the month of the issue in which the article was published.
2. The number following the hyphen is the number of the page on which the article appears in that issue.
3. The letter indicates the link in which the term was used. Where necessary the terms used to describe the information in a document may be divided into links to separate sets of terms which describe unrelated information.
4. The number in parentheses is the role in which the term was used in describing the information in the article.

While comparing the numbers listed under the two terms SYNTHESIS and CYCLOHEXANE the searcher notes on a piece of paper those numbers which are common to both terms. The numbers are common if the first three parts of the number (month, page and link) are identical. However, an additional requirement is that the role (the number in parentheses) for each term must agree

BENZENE	CYCLOHEXANE	HYDROGENATION	SYNTHESIS
2-171 (6)	4-157 (2)	3-113 (10)	3-109A (8)
3-109A (9)	11-159 (2)	4-157 (10)	3-121 (8)
3-109B (4)	11-181 (2)	5-121 (9)	4-157 (8)
3-121 (2)	11-216 (5)	5-129 (9)	5-163 (8)
4-157 (1)		7-114 (9)	5-171 (8)
7-165 (5)		7-131 (9)	5-187 (8)
8-123 (9)			
8-141 (2, 9)			

FIGURE 1—Four example term records of the format used in the HP/PR Annual Index

with the role in which the term was used in the search statement. In our example, we find that article number 4-157 is identical under both the terms SYNTHESIS and CYCLOHEXANE. Furthermore, for this article number, the role under the term SYNTHESIS is Role 8 and the role under the term CYCLOHEXANE is Role 2, both of which agree with the roles used in the search statement. Thus, article 4-157 is a source reference; that is, it is an article in which a primary topic of consideration is the synthesis of cyclohexane.

Continuing the search, the searcher will compare the list of references noted from coordinating SYNTHESIS and CYCLOHEXANE with the numbers listed under BENZENE. Any common numbers resulting from this comparison and which occur with Role 1 under BENZENE represents articles in which a primary topic of consideration is the synthesis of cyclohexane from benzene. Again looking at Figure 1, article 4-157 appears under BENZENE in Role 1. Thus article 4-157 continues to appear to be a pertinent source.

In the final step, the searcher will compare those source references which have resulted from the coordination of SYNTHESIS, CYCLOHEXANE and BENZENE with the numbers listed under HYDROGENATION. Any common numbers in the comparison which occur with Role 10 under HYDROGENATION represent articles in which a primary topic of consideration is the synthesis of cyclohexane from benzene by hydrogenation. This is identical to the search statement with which we started. In Figure 1 we again find article 4-157 listed under HYDROGENATION in Role 10 which means it is a source reference for the complete search statement.

Using the numbers of articles thus obtained, the searcher can check the title and author lists furnished in the first part of the index to see whether the articles seem pertinent enough to warrant obtaining the original article. The final step in retrieval will be to locate the original articles using the identifying numbers. The first part of the reference number directs the searcher to the month the article was published and the second number to the page in that issue.

We have now discussed the basic techniques involved in using the new HP/PR Annual Index. For the engineer or technician using the index, the treatment presented thus far will probably suffice.

However, those people who are professionally involved in information handling will be interested in the following further explanations of techniques which can be used to improve the efficiency of the retrieval operation.

Varying The Number Of Terms. It is nearly always true that the more specific or the more detailed the search statement, the fewer the source references which will be retrieved. One factor which reflects the detail of the search statement is the number of terms required to represent the search statement. The previous example required four terms or term-roles: SYNTHESIS-8, BENZENE-1, CYCLOHEXANE-2, HYDROGENATION-10.

If coordination of these four terms produces no retrievals, it might be that the search statement is too detailed for the collection of articles available. It may be made less detailed by removing terms of lesser importance one at a time, until more source references are retrieved. These, of course, will be references to more general (less specifically defined) information. For exam-

ple, the search statement reduced to SYNTHESIS-8, CYCLOHEXANE-2, would retrieve references to articles which discuss the "synthesis of cyclohexane" from any or all inputs or reactants and by any or all processes.

Substituting Generic Terms. A factor which determines the specificity of the information retrieved is the level of specificity of the individual terms used in the search statement. Again, if the above example had resulted in no retrievals, the retrieval of more general but related articles might be achieved by substituting generic terms for the specific terms. This treatment of the terms CYCLOHEXANE and BENZENE in the above example would produce the following term-roles to be coordinated: SYNTHESIS-8, CYCLOALKANES-2, AROMATIC HYDROCARBONS-1, HYDROGENATION-10. This search would retrieve source references to articles in which "a primary topic of consideration is the synthesis of cycloalkanes from aromatic hydrocarbons by hydrogenation."

Vocabulary Control. Generics (demonstrated above) and semantics are two language problems which can result in failure to retrieve pertinent information. Semantics is primarily a problem of meanings of words, of synonymity and near-synonymity. Uncontrolled semantics could result in failure to locate references pertinent to the inquiry because the search statement includes a synonym or near-synonym for a term which was used in indexing.

Generics involves the problems of word families and their relationships. Assume that the search statement were "The primary topic of consideration is the efficiency of pumps." This inquiry should retrieve articles which discuss the efficiency of pumps in general as well as those which discuss the efficiency of centrifugal pumps, since they are specific members of the broader class or family represented by the generic term PUMPS. The article which discusses only the "efficiency of centrifugal pumps" will not be retrieved when we want articles which discuss the "efficiency of pumps" unless vocabulary control is applied in such a way that the generic term PUMPS automatically includes its specific members, such as CENTRIFUGAL PUMPS. Vocabulary control must be applied either in indexing or retrieval or both!

Control of semantics and generics in inverted coordinate indexes is accomplished by use of a thesaurus. The terms used in the HP/PR 1963 index were selected with the aid of the Chemical Engineering Thesaurus.[10] It can be used to help you form a search question by suggesting related terms to those you think of when forming a question. A new *Thesaurus of Engineering Terminology* is now in preparation by the Engineers Joint Council. It will be available through EJC early in 1964. Several references[5,6,7,8,9,10,11] discuss the development and use of thesauri in detail.

Multiple Roles For Complete Searches. To obtain the articles which discuss, in *any context*, the "synthesis of cyclohexane from benzene by hydrogenation," the searcher should frame several search statements. The following term-roles SYNTHESIS-7, BENZENE-1, CYCLOHEXANE-2, HYDROGENATION-10 would retrieve references to articles in which "a primary topic of consideration is the effect of something (perhaps temperature or pressure) on the synthesis of cyclohexane from benzene by hydrogenation."

The term roles: SYNTHESIS-9, BENZENE-1, CYCLOHEXANE-2, HYDROGENATION-10 would retrieve references to articles in which "a primary topic of consideration is, perhaps, the rate of the synthesis of cyclohexane from benzene by hydrogenation."

The term-roles: SYNTHESIS-4, BENZENE-1, CYCLOHEXANE-2, HYDROGENATION-10 would retrieve reference to articles in which "a primary topic of consideration is, perhaps, reactors for use in synthesizing cyclohexane from benzene by hydrogenation."

Thus, additional searches using SYNTHESIS, the original Role 8 term, in Roles 4, 7, or 9 will retrieve references to articles which apply to the topic of the search but in which synthesis was not considered to be the *primary* topic of consideration.

Redundancy In Searching. While every effort is made to standardize indexing through use of prescribed ground rules, some inconsistency is inevitable. The technique used to compensate for inconsistency is redundancy, both in indexing the source articles and in forming the search statements. Redundancy is applied in retrieval by forming several differently phrased search statements. To illustrate, the search statement "the primary topic of consideration is the prevention of corrosion of copper pipes using plastic coatings," is expressed in the following term-roles: PREVENTION-8, CORROSION-9, COPPER-1, PIPES-1, PLASTICS-10, COATINGS-10. The same basic idea could be expressed as "The primary topic of consideration is plastic coatings for use in preventing corrosion of copper pipes." This search statement is expressed in the following term-roles: COATINGS-8, PLASTICS-8, PREVENTION-4, CORROSION-9, COPPER-1, PIPES-1. Redundant searching means that whenever it is possible to phrase an inquiry in more than one way, all expressions of the inquiry should be converted to their correct search statements and then to the sets of term-roles to be searched. This will assure that all pertinent source references will be retrieved.

Indexing Ground Rules. In coordinate indexing with links and roles, experience has shown that certain ground rules must be established and followed consistently. These ground rules serve to standardize indexing in areas where individual indexers might be inconsistent. The objective of ground rules is to develop and maintain consistency in indexing so that searches for source references will be effective and complete.

Ground rules applied in indexing original articles must be applied in indexing search statements to assure retrieval of all articles pertinent to the search statement and to minimize the number of non-pertinent source references retrieved. It is not possible to discuss in detail the ground rules used in the preparation of the Petroleum Refiner Index. However, the ground rules are presented in the Engineers Joint Council training course publications available through Battelle Memorial Institute.

Logical Product, Sum, Difference.[12] In the examples demonstrated up to this point, we have made use only of the logical product in formulating search strategies.

Two other techniques which sometimes must be used are logical sum and logical difference.

Restating the basic example used previously as follows, we can demonstrate an inquiry which would require the use of logical sum in conducting the search.

The inquiry. "Are there any articles which discuss the synthesis of cyclohexane from either benzene or toluene?"

The search statement. "The primary topic of consideration is the synthesis of cyclohexane from benzene or toluene."

The term-roles: SYNTHESIS-8, BENZENE-1, CYCLOHEXANE-2,

and: SYNTHESIS-8, TOLUENE-1, CYCLOHEXANE-2.

The element in this inquiry which requires the use of the logical sum is the phrase "benzene *or* toluene." In performing the logical sum it becomes necessary to search two parallel sets of term-roles as shown above. Source references retrieved from searching *both* of these sets of term-roles will represent articles which are pertinent to the inquiry.

Restating the example once more will demonstrate the need for logical difference.

The inquiry. "Are there any articles which discuss the synthesis of cyclohexane from benzene by any means but a platinum catalyst."

The search statement. "The primary topic of consideration is the synthesis of cyclohexane from benzene except where platinum is used as a catalyst."

The term-roles: SYNTHESIS-8, BENZENE-1, CYCLOHEXANE-2,

and: SYNTHESIS-8, BENZENE-1, CYCLOHEXANE-2, PLATINUM-10, CATALYSTS-10.

The element in this inquiry which requires the use of logical difference is the phrase "except where platinum is used as a catalyst." In performing the logical difference it becomes necessary to search two parallel sets of term-roles as shown above. Source references which result from the second set of term-roles must be "deducted" from the source references which result from the first set. That is, any source references that result from (or are common to) *both* sets of term-roles must be disregarded as representing articles which are not pertinent to the inquiry.

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